Efficiency estimation of the SVD with DESY test beam data (April 2016)

Thomas Lück for the Pisa-group

September 15, 2016

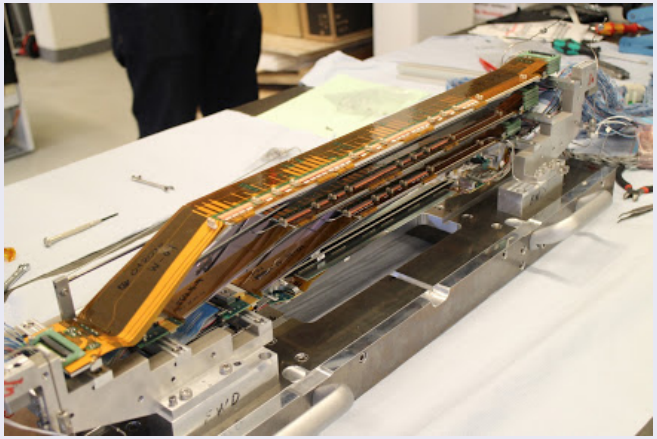
outline

- DESY beam test setup
- Hit efficiency measurement
- Measurement of the residuals
- Track finding at the test beam
- Summary

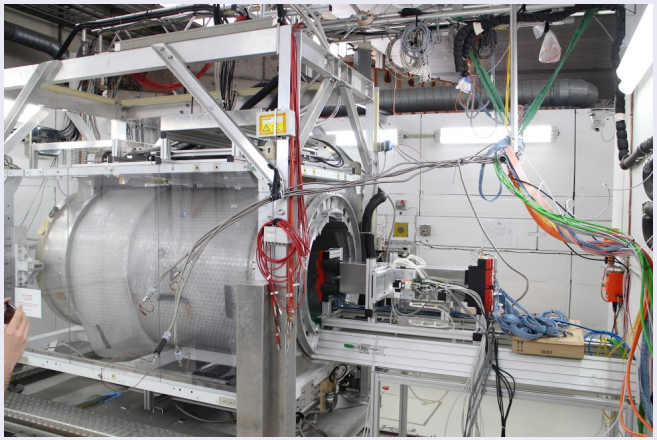
Experimental setup at DESY (Hamburg)

- combined test PXD + SVD
- e^- beam: $p = 2 - 5$GeV
- full readout chain same, geometry as Beast 2
- B-field: 0 - 1 T
- a total of around 340 runs
- ≈12 good runs (190 mio evt)

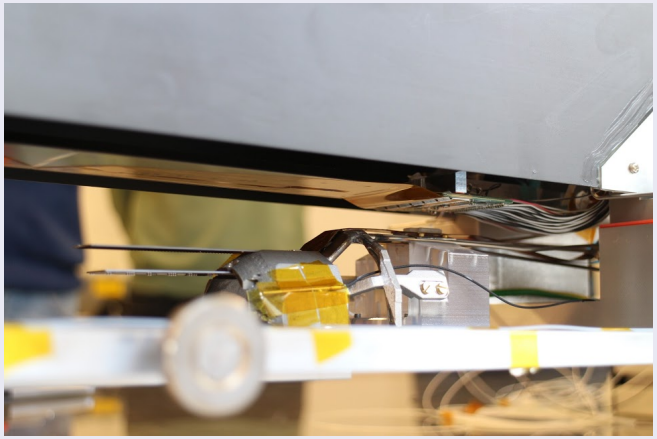
4 ladders SVD (without PXD)



VXD + magnet



2 PXD half ladders (under SVD)



pictures by Katsuro Nakamura

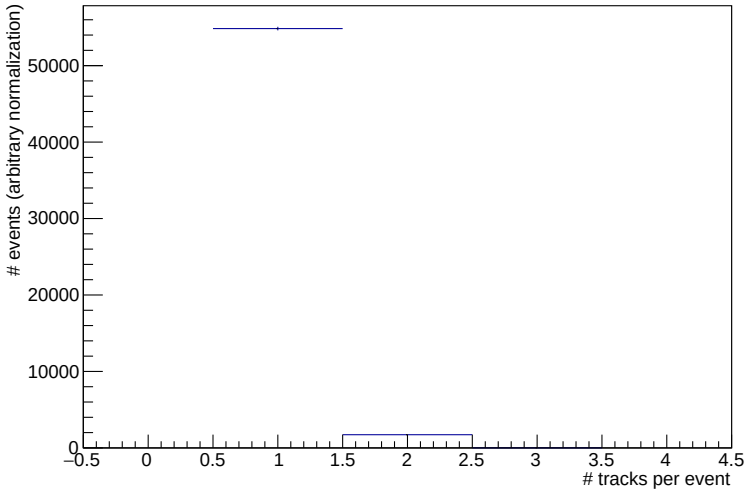
Hit efficiency measurement

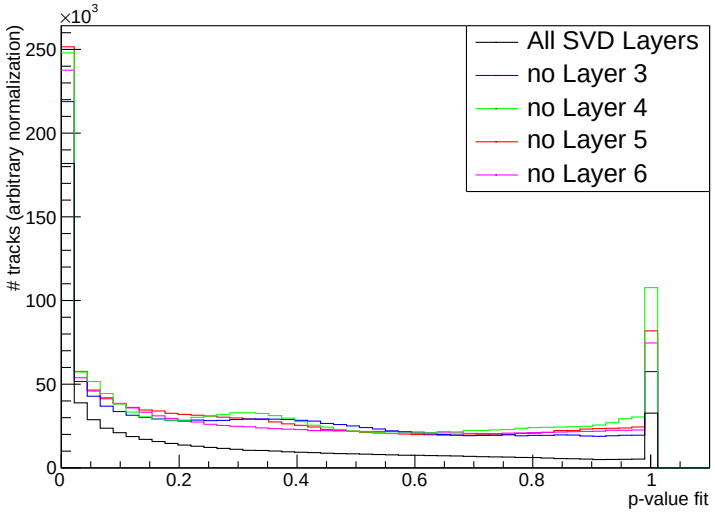
Procedure

- avoid correlation between track finding and efficiency and do track finding and fitting on 3 of the 4 SVD layers
- use dedicated sector maps for VXDTF:
  - trained on 3 out of the 4 SVD layers
  - found track candidates contain only hits on the 3 SVD layers used for training
- use fitted track to predict position on the remaining layer (not used for tracking)
- count the number of hits (strips or clusters) within $300\mu m$ of the predicted track position
- calculate:
  - efficiency: $\epsilon = \frac{\#hits}{\#tracks}$
  - or inefficiency: $\eta = 1 - \epsilon$

Event selection

- P-value for the track fit of $P > 0.02$
- only events with single track
- select only "high" momentum tracks $2 < p_{fit} < 4\ GeV$
- require a good accuracy of the extrapolated track position on the sensor:
  - fit uncertainty $< 30 - 70\ \mu m$ (depending on layer and side)
- noisy and bkg. strips are masked

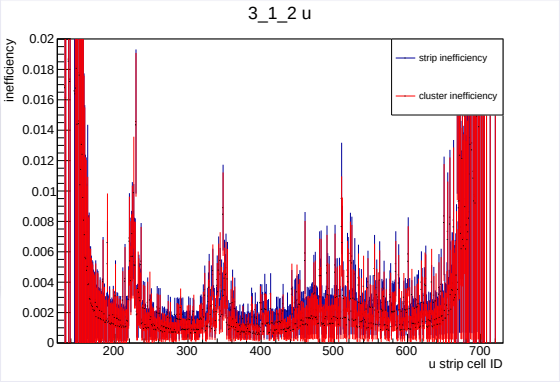


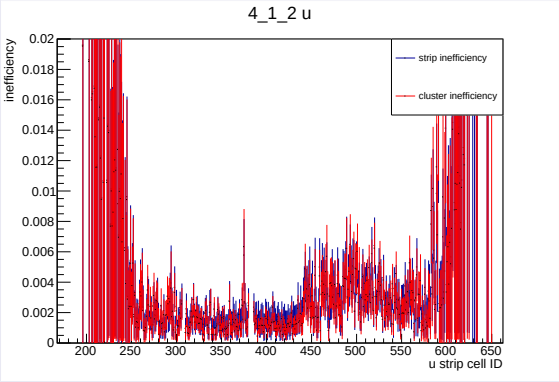


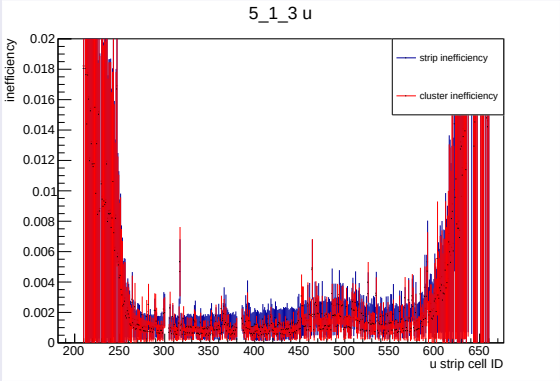
Preliminary results for inefficiencies u-direction

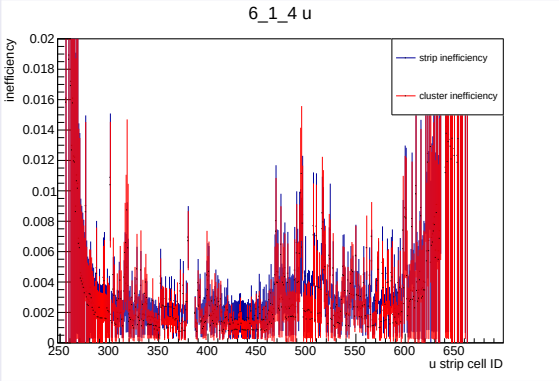
- very high efficiencies
- some ineffiecies by known defects, new defects and selection

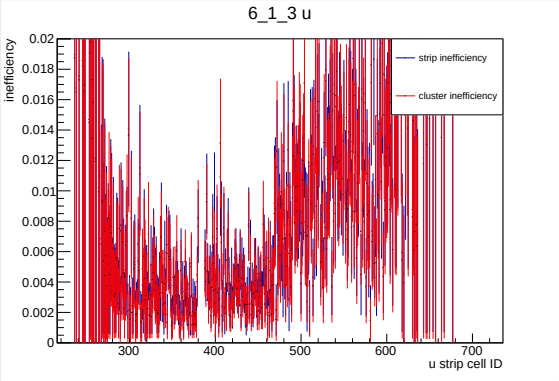
- shown are only strips which see beam







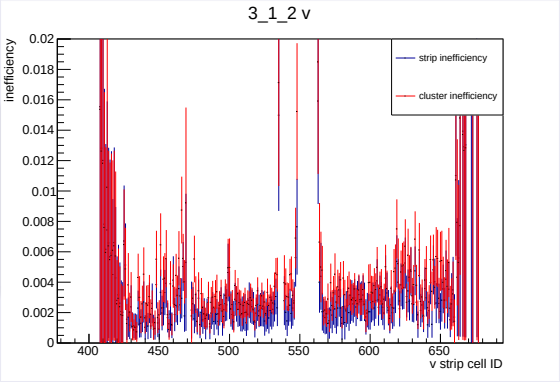


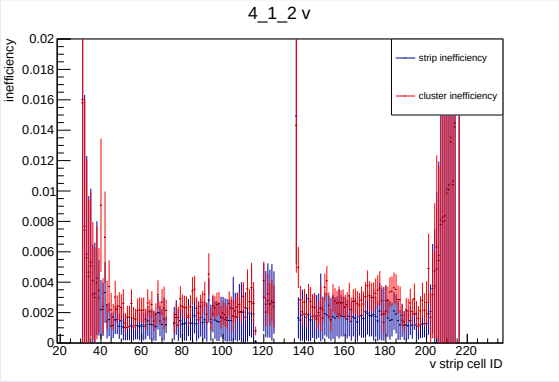


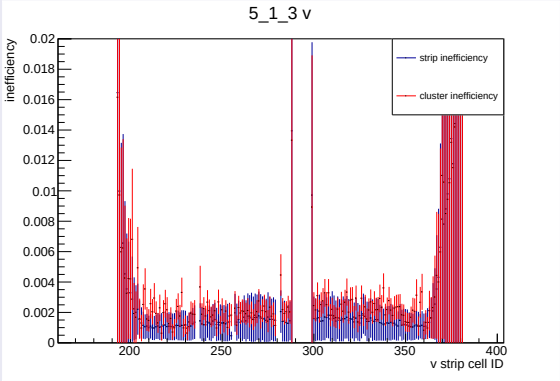
Preliminary results for inefficiencies v-direction

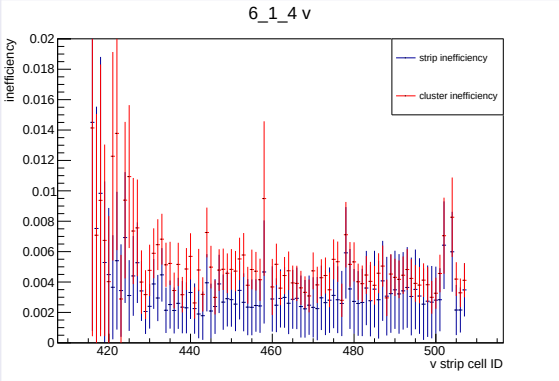
- very high efficiencies
- some ineffiecies by known defects, new defects and selection

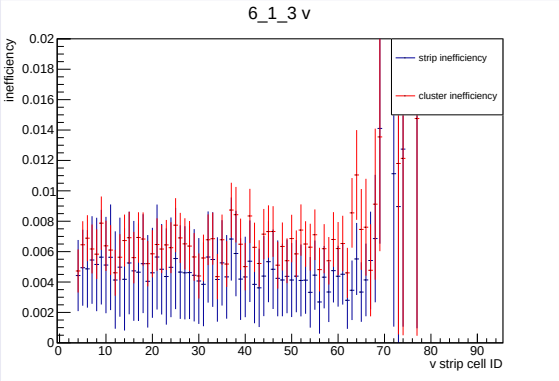
- shown are only strips which see beam





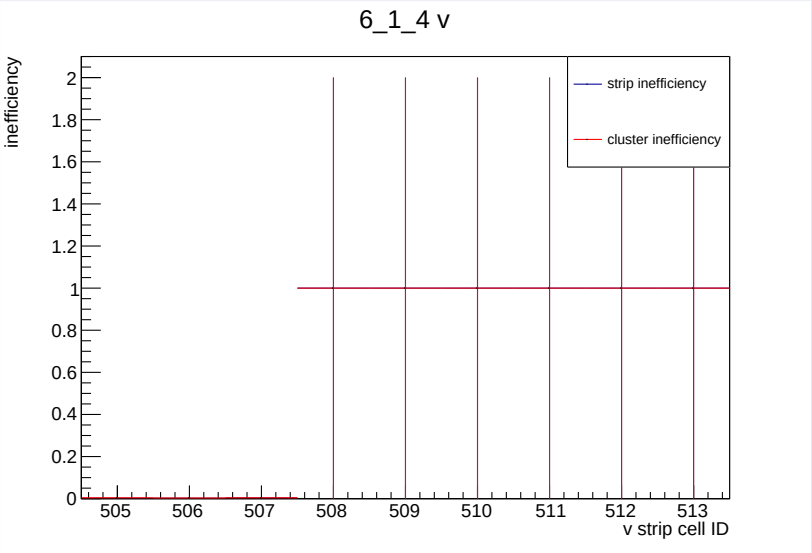


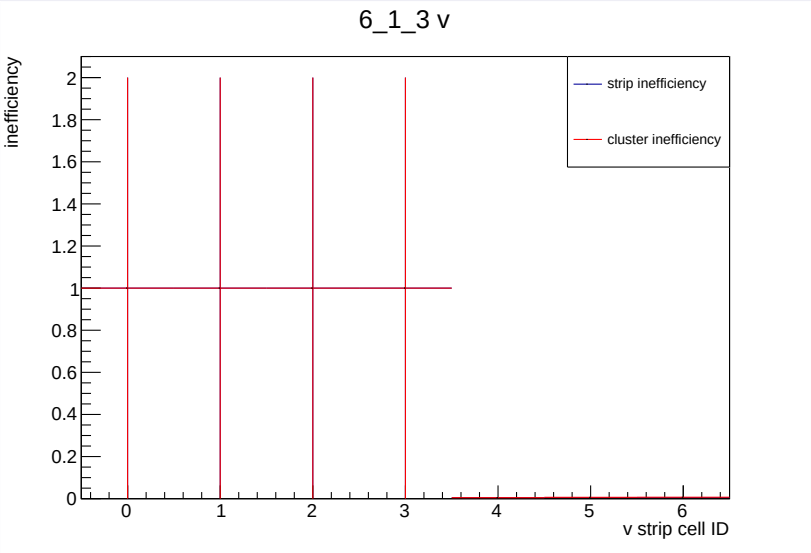




Issue of possible inefficiency at the edges

- Katsuro mentioned that strips close to the sensor edges have an inefficiency 1.0 (see his talk from yesterday p.34)
- seen for the last and first four strips of the sensors on layer 6
- bottom plots show an zoomed version for the inefficiency shown yesterday
- please note: the last strip is #511!



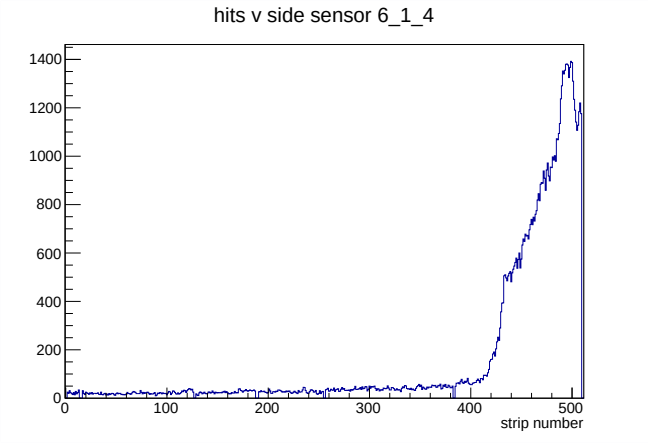


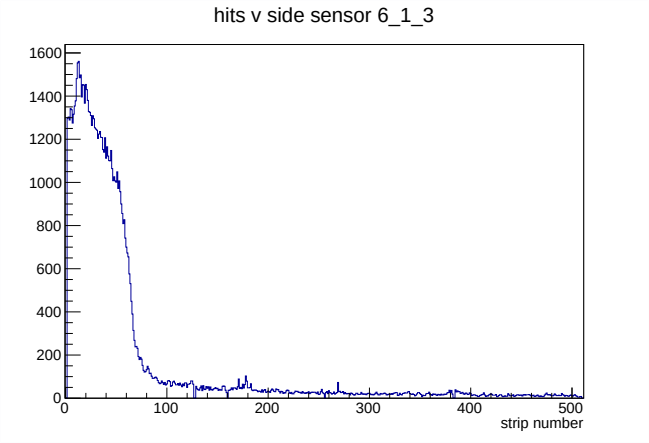
The Reason

- only events where the track is at least 1mm away from the sensor edge (active volume) are selected for the analysis
- 1mm corresponds approximately to 4 strips in v-direction (n - side)
- cut was chosen to avoid introduction of possible systematic effects by being close to the edges (in retrospect not wisely chosen)
- $\Rightarrow$ no (in)efficiencies are estimated (the inefficiency is set to 1.0 by default)
- $\Rightarrow$ effect introduced by the event selection and NOT by the hardware/software
- sorry for the confusion caused

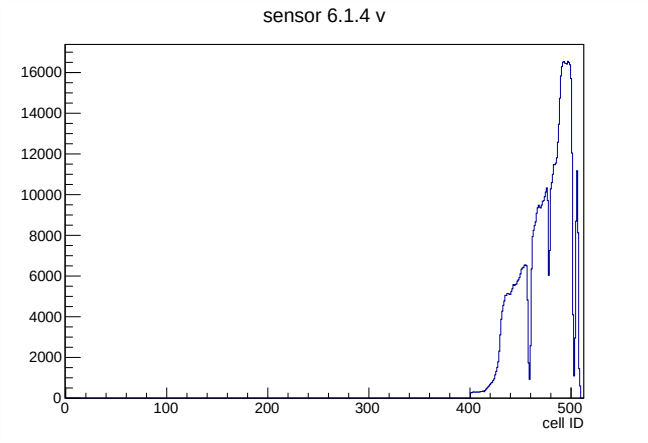
effect of event selection on reconstructed hit maps

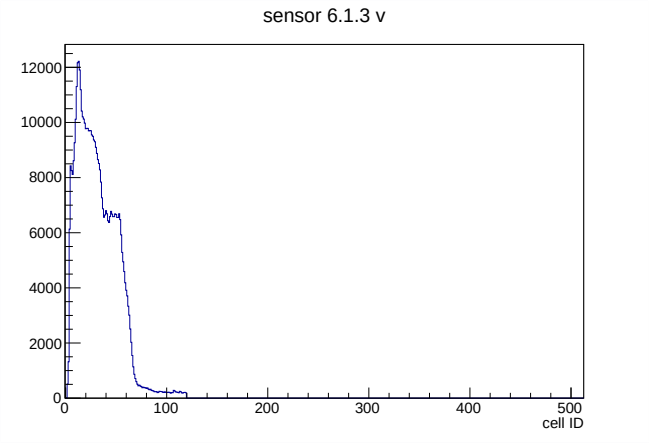
hit maps v-side layer 6, NO selection applied





hit maps v-side layer 6, event selection applied





Residual measurement

Acknowledgement

- results shown are based on the work of Benjamin Schwenker and Ulf Stolzenberg

Residual measurements

- measurement of residuals with VXD alone not possible:
  - observed correlation between fitted track position and cluster position
  - an unbiased measurement not possible
  - achievable resolution or VXD alone only on 10-30 μm (depending on layer and side)
- telescope is needed to perform residual measurement
- Benjamin and Ulf set up a framework to analyse the test beam data outside basf2 (based on the EUTelescope software package)
- kindly provided this to me (just plug and play)

Residual measurement

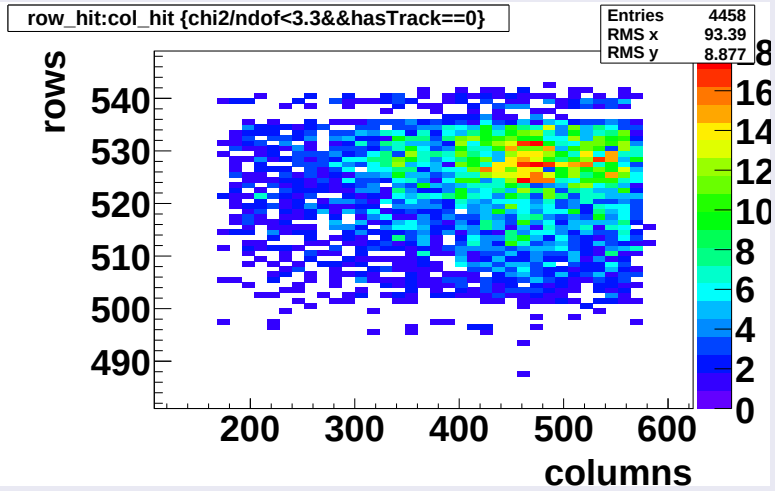
dataset

- Run 96; 5GeV electrons; no B-field (0T); 539 kEvts

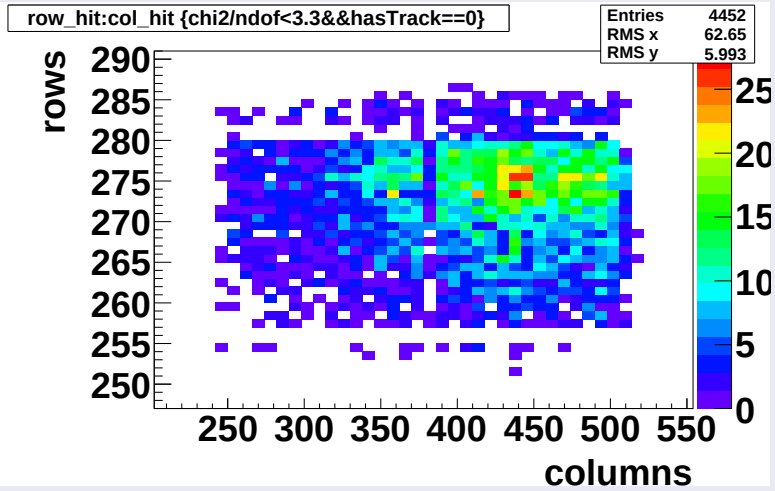
Analysis strategy

- do tracking on all 12 layers present at the TB
  - 6 Telescope planes (3 before, 3 after the VXD), 2 PXD planes, 4 SVD planes
- require at least 10 hits per track
- require for the $\chi^2/ndof < 3.3$ for the track fit to reject badly fitted tracks
- use track to measure the unbiased residual (i.e. plane under investigation not used in the track)

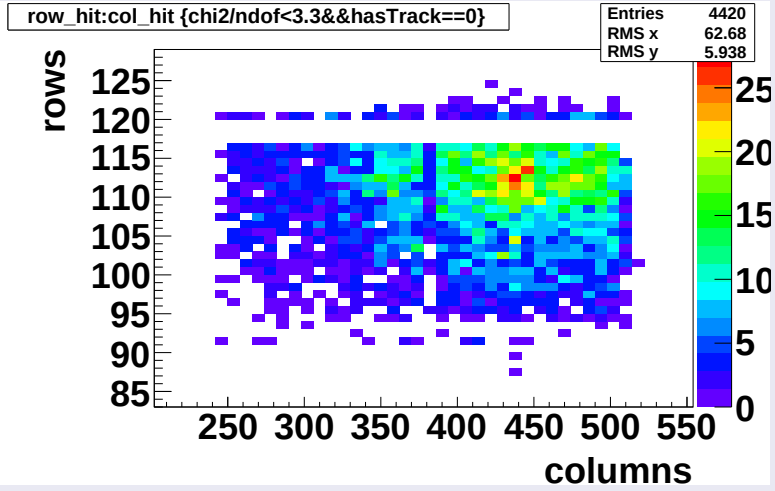
fitted hitmap layer 3



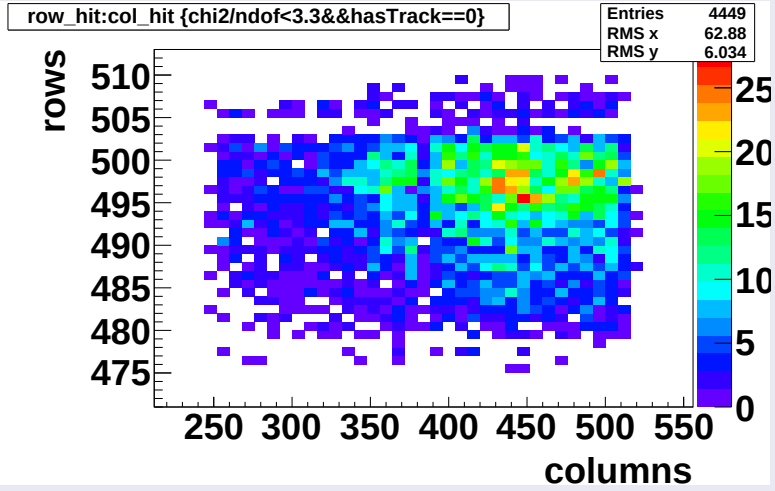
fitted hitmap layer 5



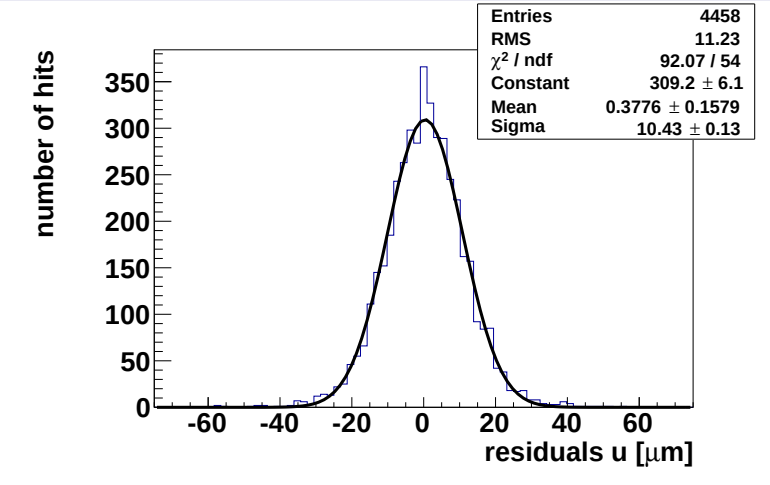
fitted hitmap layer 4



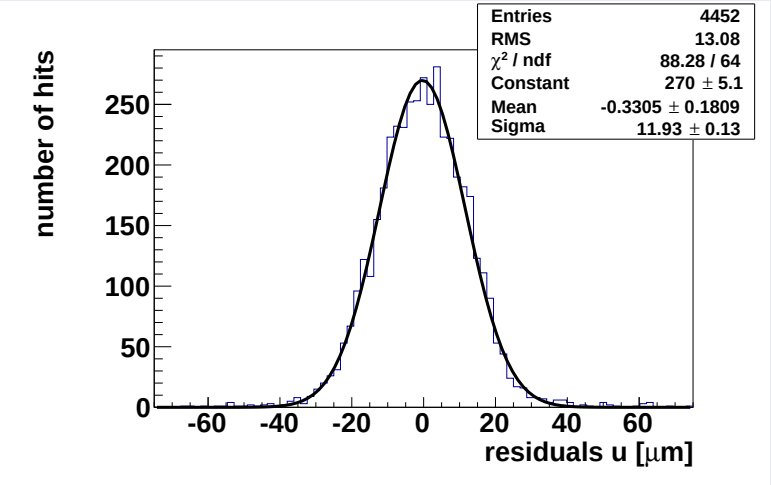
fitted hitmap layer 6



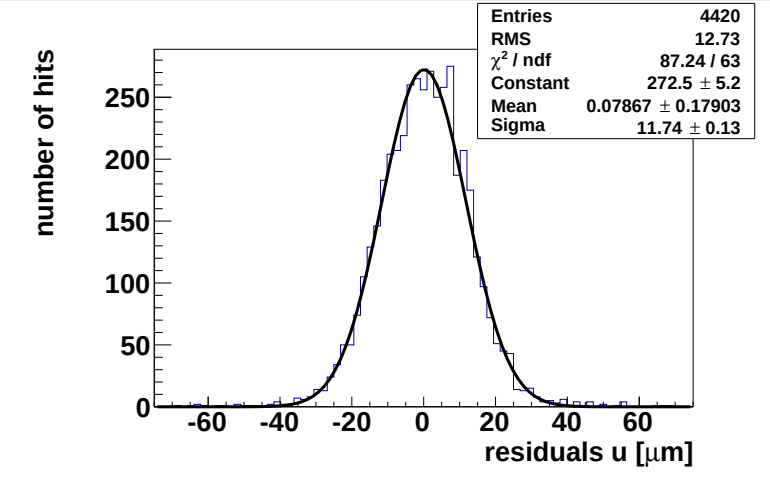
residual layer 3 in u-direction



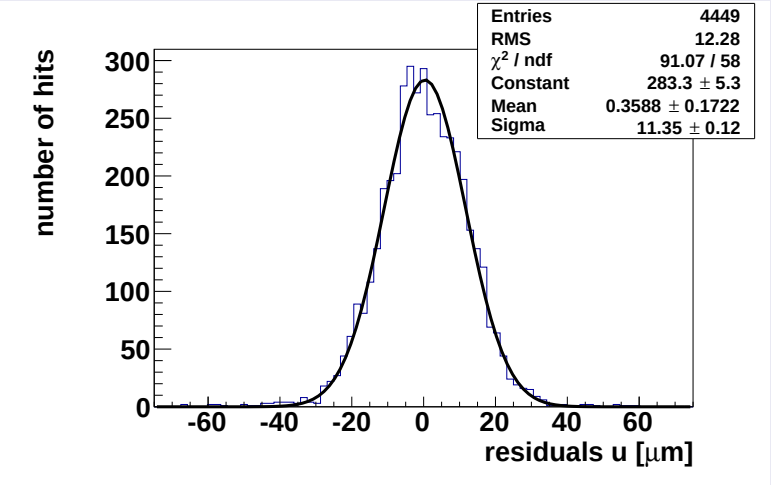
residual layer 5 in u-direction



residual layer 4 in u-direction

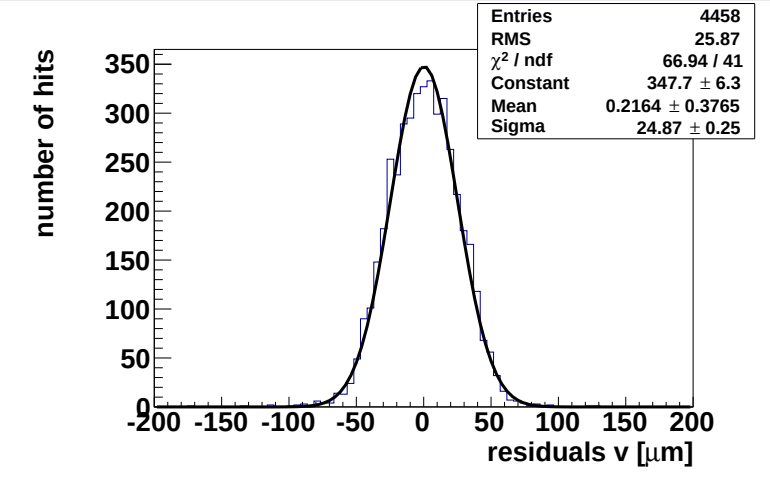


residual layer 6 in u-direction

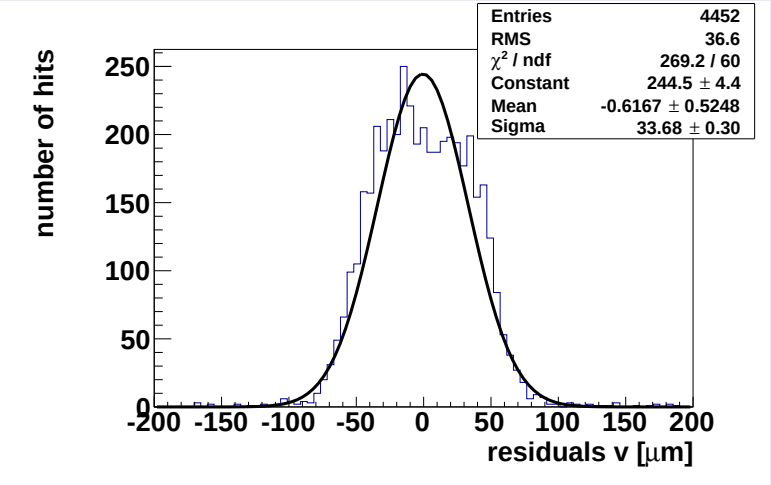


Note: possible background in the tails of the gaussian

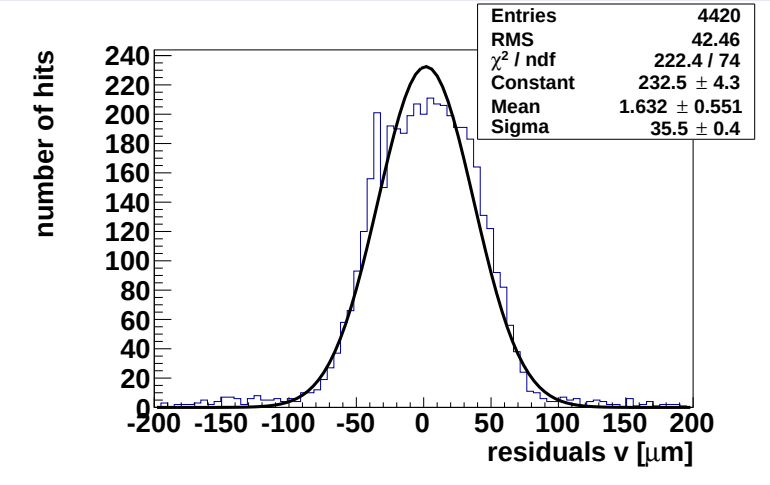
residual layer 3 in v-direction



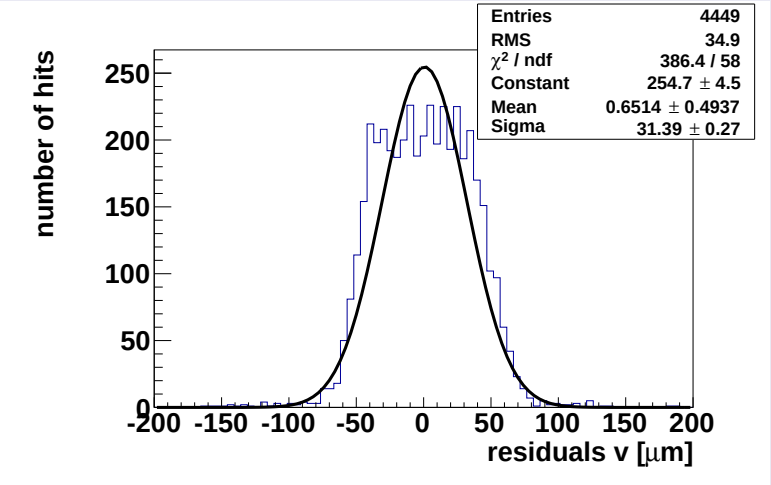
residual layer 5 in v-direction



residual layer 4 in v-direction



residual layer 6 in v-direction



Note: possible background in the tails of the gaussian

- σ_{gauss} : width of a Gaussian fitted to the residual
- $\sqrt{\sigma_{gauss}^2 - \sigma_{trackFit}^2}$: correct for the uncertainty of the track position prediction $\sigma_{trackFit}$ (u-direction: $\approx 6 - 7\mu$m, v-direction: $\approx 8\mu$m)

Results u-direction (p-Side)

ladder	RMS	σ_{gauss}	$pitch/2\sqrt{12}$	$\sqrt{\sigma_{gauss}^2 - \sigma_{trackFit}^2}$
L3	11.23	10.43 ± 0.13	7.22	8.16
L4	12.73	11.74 ± 0.13	10.83	9.78
L5	13.08	11.93 ± 0.13	10.83	10.00
L6	12.28	11.35 ± 0.12	10.83	9.30

Results v-direction (n-Side)

ladder	RMS	σ_{gauss}	$pitch/2\sqrt{12}$	$\sqrt{\sigma_{gauss}^2 - \sigma_{trackFit}^2}$
L3	25.87	24.87 ± 0.25	23.09	23.55
L4	42.46	35.5 ± 0.4	34.64	34.59
L5	36.6	33.68 ± 0.30	34.64	32.72
L6	34.9	31.39 ± 0.27	34.64	30.35

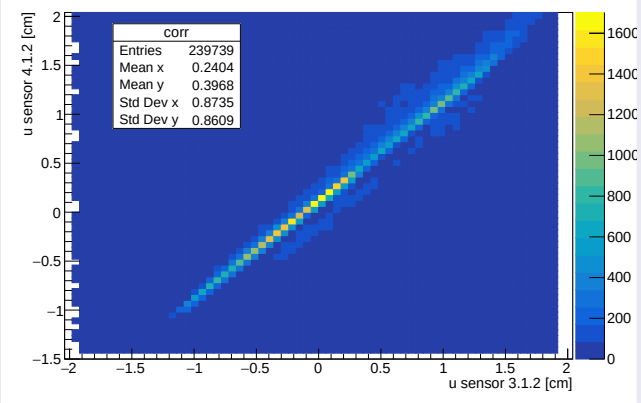
Track finding/fitting inefficiency

- no cuts applied on track
- tracks found with all 4 SVD layers
- remove clusters used for tracks
- investigate remaining clusters

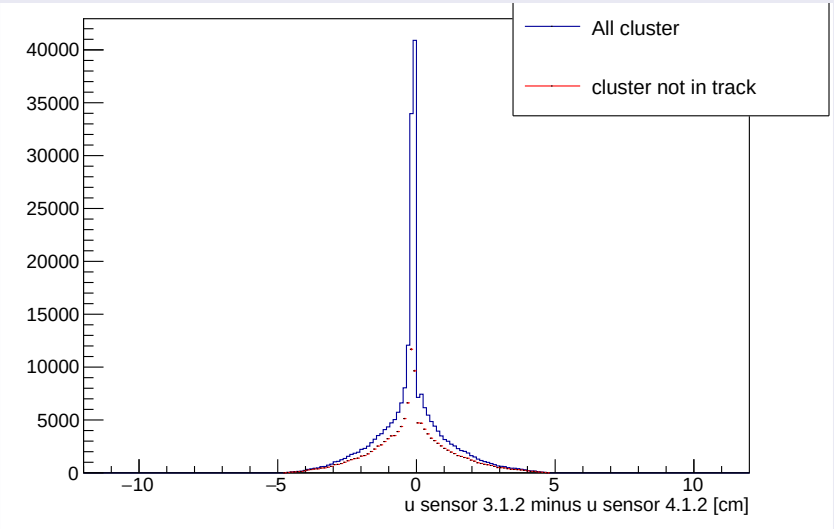
⇒ correlation between all SVD layers

⇒ "un-found" tracks

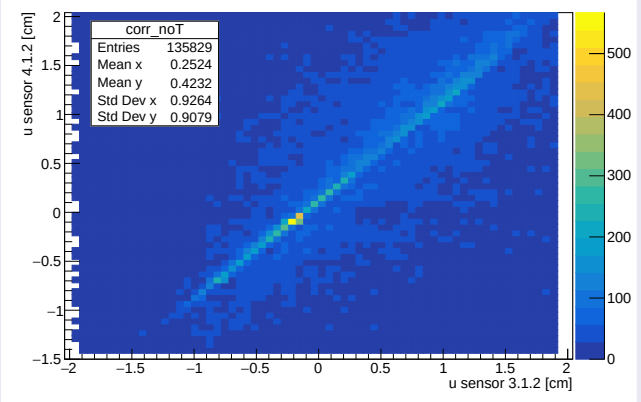
sensors 3.1.2 and 4.1.2, all cluster



difference in u position of clusters on sensors 3.1.2 and 4.1.2



sensors 3.1.2 and 4.1.2, clusters not used in track



Track finding at the upcoming beam test

- track finding in basf2 by VXD Track Finder (VXDTF)
- several problems/crashes caused by the VXDTF
- VXDTF runs on the High Level Trigger, HLT (default setting)
- VXDTF crashes ⇒ HLT stops working ⇒ NO data taking
- the VXDTF is currently redesigned: VXDTF ⇒ VXDTF2

bad news:

- VXDTF2 not ready next beam test: VXDTF(1) will be used
- VXDTF "frozen": no new features/improvements (except bug fixes)

good news:

- problems of VXDTF at April 2016 test beam are understood
- counter measures have been implemented
- the VXDTF is running stable now on data

Summary and outlook

Summary hit efficiency

- estimated the hit efficiency of the SVD
- average efficiencies $> 99\%$

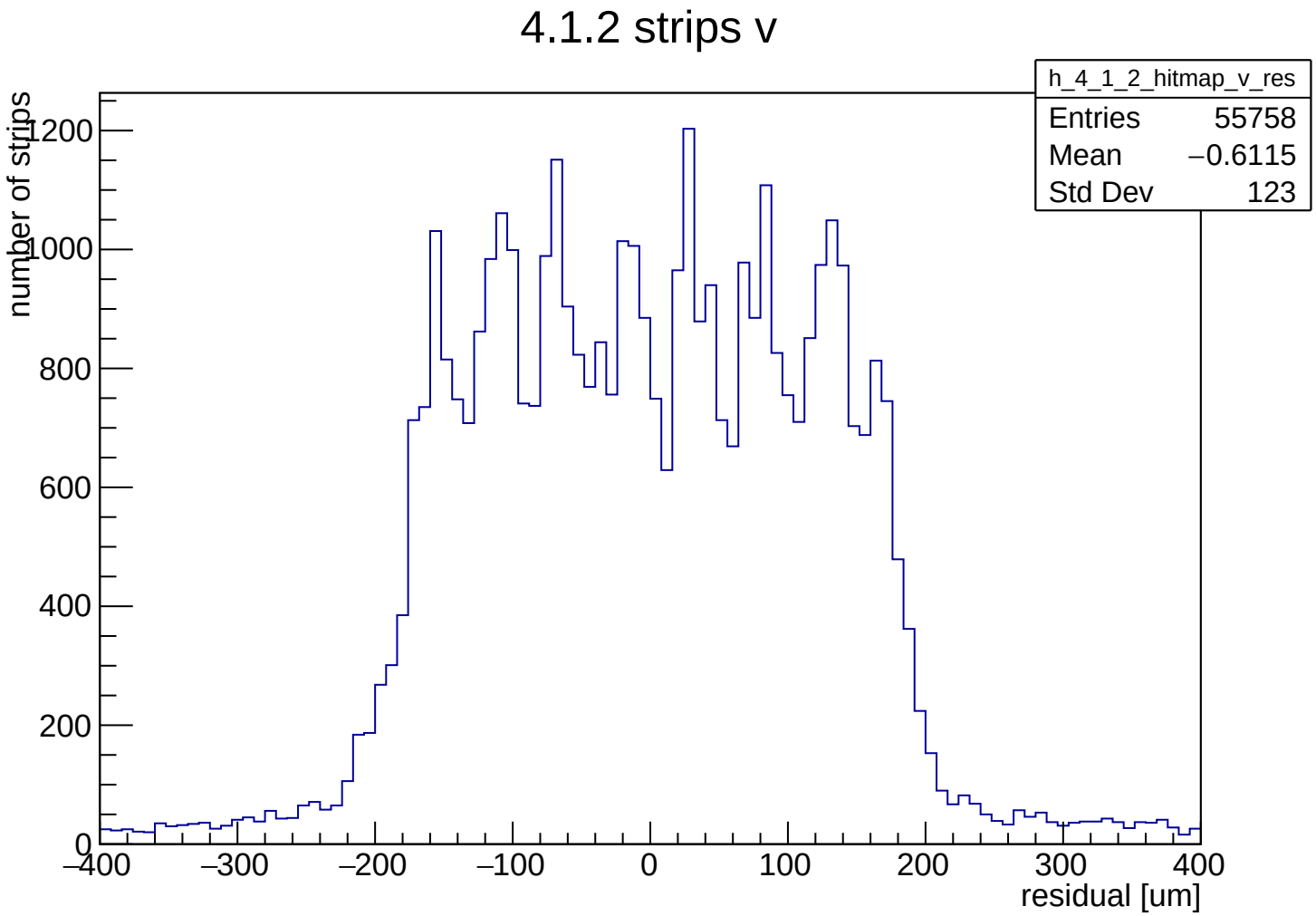
Summary Residual measurement

- residuals more or less consistent with expectation
- some residuals seem to be bit too large
- background contribution not yet studied
- use run with B-field might reduce background (sadly only one run with telescope available)

THE END

Backup

correlations between fitted track (3 Layer SVD) and reconstructed position on the SVD layer not used in the track manifest in structures seen in the residual

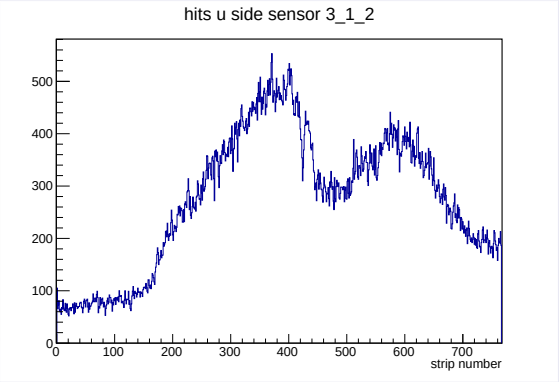


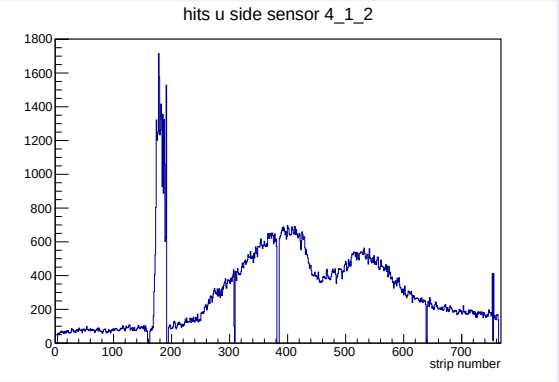
Data sample for the hit efficiency analysis: run 329

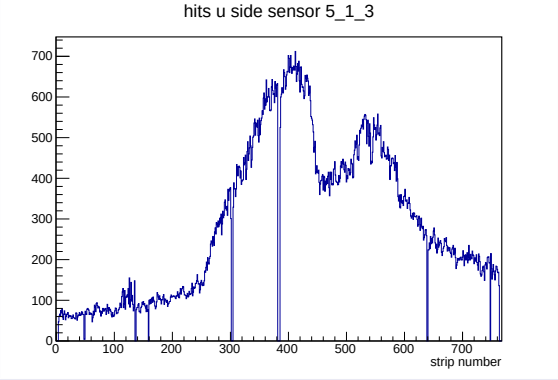
unbiased hit maps u-direction

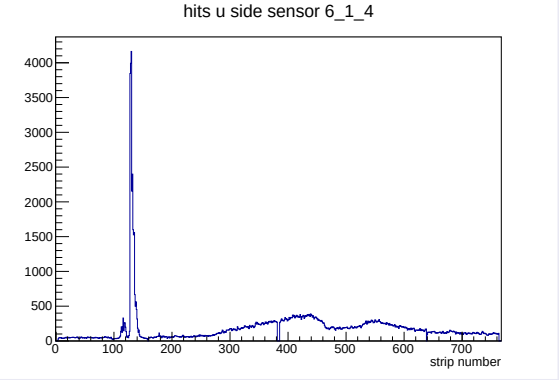
Dataset:

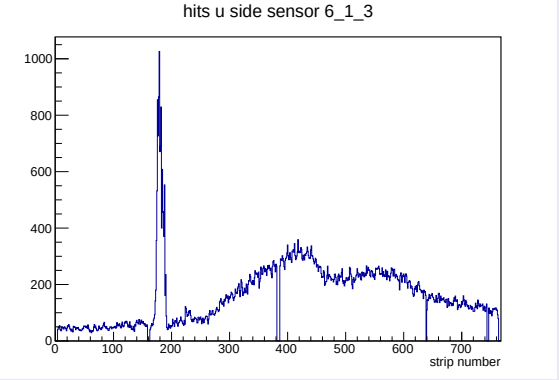
- p=5 GeV
- B-field: 1 T
- 2.3 mio evt.





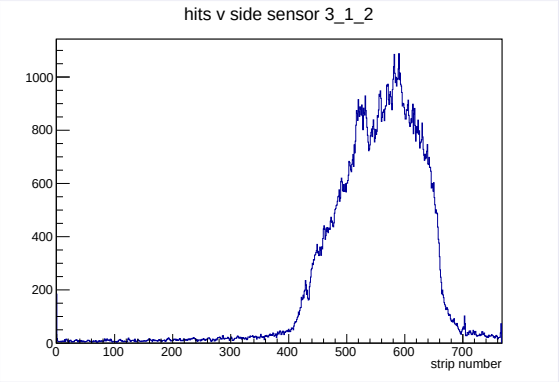
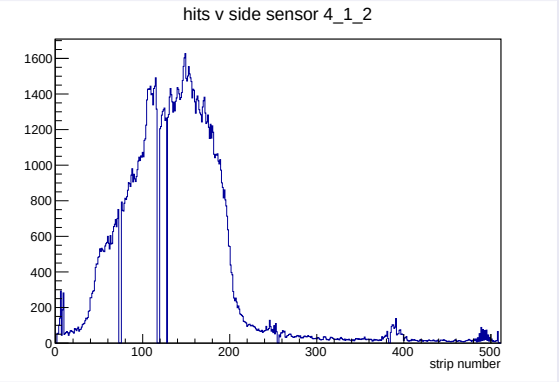
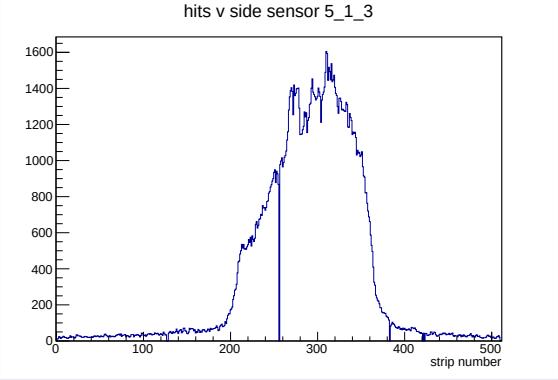
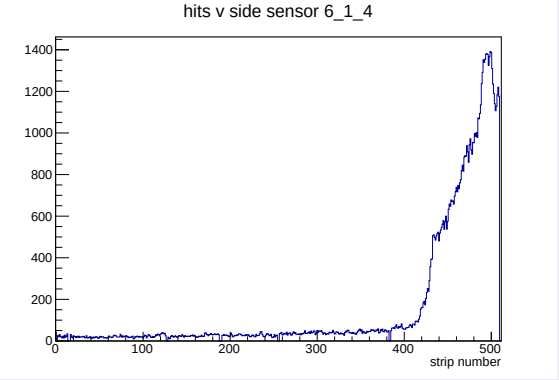
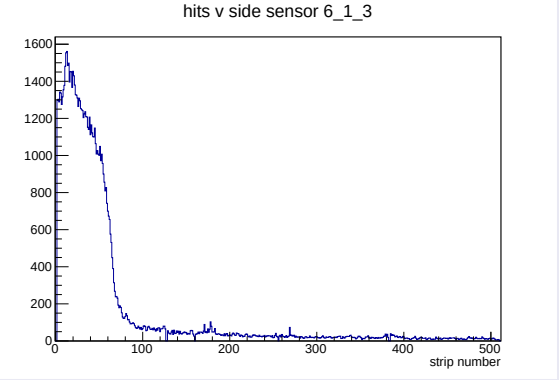






Data sample for the hit efficiency analysis: run 329

unbiased hit maps v-direction

Dataset:

- p=5 GeV
- B-field: 1 T
- 2.3 mio evt.